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Flowfield Comparisons: Tunnel 9 Case 3745

Ross Wagnild, Micah Howard, Justin Smith, Dave Kuntz





Tunnel 9 – Run 3745



- Conditions and geometry from AIAA-2014-3108
 - $T_{\infty} = 54.42 \text{ K}; \rho_{\infty} = 4.861123e 3 \text{ kg/m}^3; U_{\infty} = 1413.083 \text{ m/s}$
 - Sphere cone 7° half-angle, nose radius 0.006 inches



- Sandia Grid
 - 20 cells on the nose; 800 on the body; 200 cells wall-normal
 - Manually shock tailored
- Sandia Computations made with SPARC
 - Cell-centered finite volume using Modified Steger-Warming and Roe inviscid flux schemes
 - Minmod limiter using MUSCL TVD scheme
 - Viscous fluxes evaluated using weighted-least squares gradients

Stagnation Line Comparisons: 2nd Order Sandia National Inhoratories



Mach Number

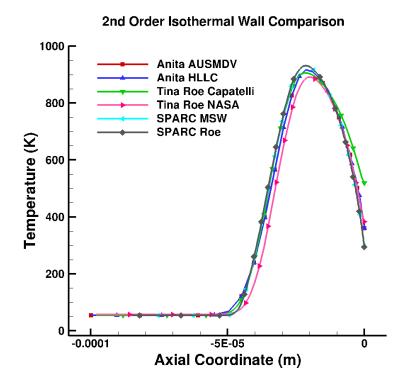
-0.0001

2nd Order Isothermal Wall Comparison Anita AUSMDV **Anita HLLC** Tina Roe Capatelli Tina Roe NASA SPARC MSW **SPARC Roe** Mach

-5E-05

Axial Coordinate (m)

Temperature



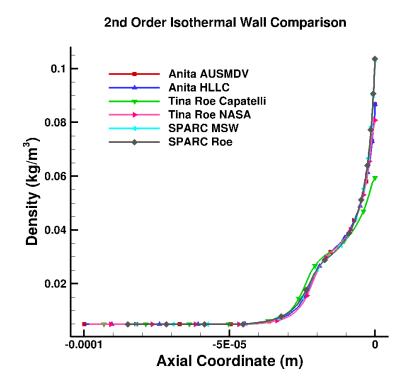
Stagnation Line Comparisons: 2nd Order Sandia National Inhoratories



Pressure

2nd Order Isothermal Wall Comparison Anita AUSMDV Anita HLLC 8000 Tina Roe Capatelli Tina Roe NASA SPARC MSW **SPARC Roe** Pressure (Pa) 2000 -0.0001 -5E-05 **Axial Coordinate (m)**

Density

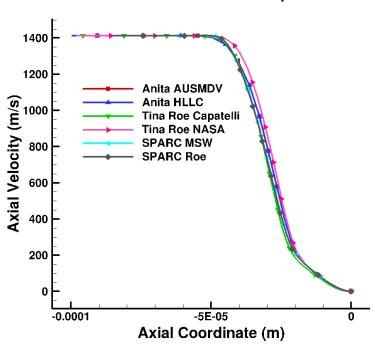


Stagnation Line Comparisons: 2nd Order Sandia National Inhoratories</sup>



Velocity

2nd Order Isothermal Wall Comparison





Mach Number

Adiabatic Wall Comparison Anita AUSMDV 1st Order Anita Hanel 2nd Order SPARC MSW 2nd Order SPARC Roe 2nd Order Mach

-4E-05

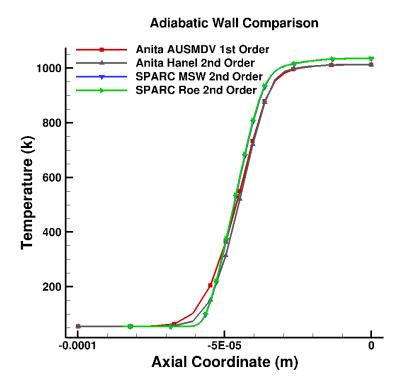
Axial Coordinate (m)

-2E-05

-6E-05

-8E-05

Temperature

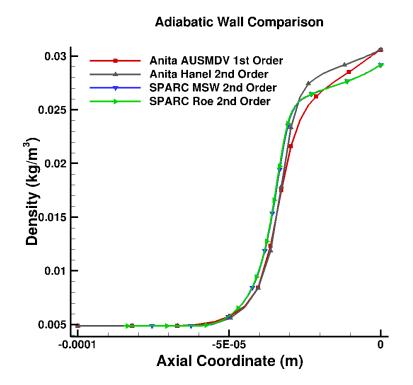




Pressure

Adiabatic Wall Comparison Anita AUSMDV 1st Order Anita Hanel 2nd Order 8000 SPARC MSW 2nd Order SPARC Roe 2nd Order Pressure (Pa) 2000 -0.0001 -5E-05 **Axial Coordinate (m)**

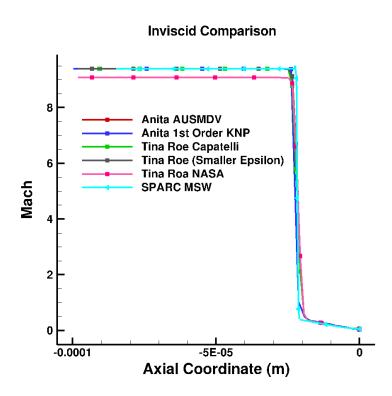
Density



Stagnation Line Comparisons: Inviscid



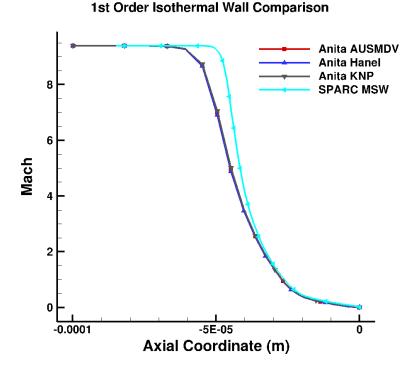
Mach Number



Stagnation Line Comparisons: 1st Order Sandia National Laboratories

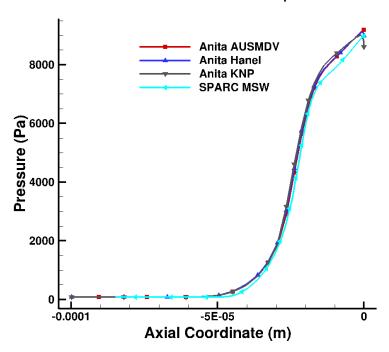


Mach Number



Pressure

1st Order Isothermal Wall Comparison

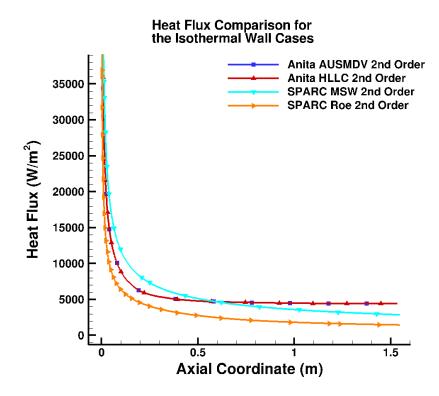


Surface Heat Flux Comparisons: 2nd Order



Nose

Heat Flux Comparison for the Isothermal Wall Cases Anita AUSMDV 2nd Order Anita HLLC 2nd Order SPARC MSW 2nd Order 2E+06 SPARC Roe 2nd Order Heat Flux (W/m²) .5E+06 1E+06 500000 0.0002 5E-05 0.0001 0.00015 Axial Coordinate (m)

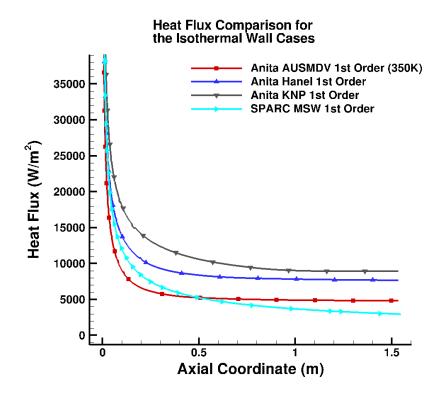


Surface Heat Flux Comparisons: 1st Order



Nose

Heat Flux Comparison for the Isothermal Wall Cases Anita AUSMDV 1st Order (350K) Anita Hanel 1st Order Anita KNP 1st Order 2E+06 SPARC MSW 1st Order Heat Flux (W/m²) .5E+06 1E+06 500000 5E-05 0.0001 0.00015 0.0002 Axial Coordinate (m)

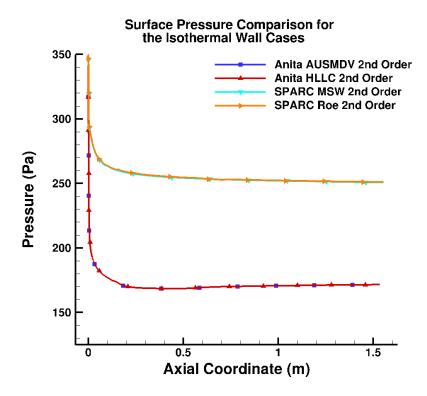


Surface Pressure Comparisons: 2nd Order



Nose

Surface Pressure Comparison for the Isothermal Wall Cases Anita AUSMDV 2nd Order Anita HLLC 2nd Order SPARC MSW 2nd Order 8000 SPARC Roe 2nd Order Pressure (Pa) 6000 4000 2000 5E-05 0.0001 0.00015 0.0002 Axial Coordinate (m)

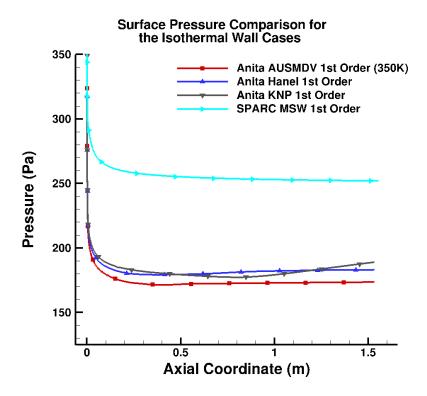


Surface Pressure Comparisons: 1st Order



Nose

Surface Pressure Comparison for the Isothermal Wall Cases Anita AUSMDV 1st Order (350K) Anita Hanel 1st Order Anita KNP 1st Order 8000 SPARC MSW 1st Order Pressure (Pa) 6000 4000 2000 5E-05 0.0001 0.00015 0.0002 Axial Coordinate (m)

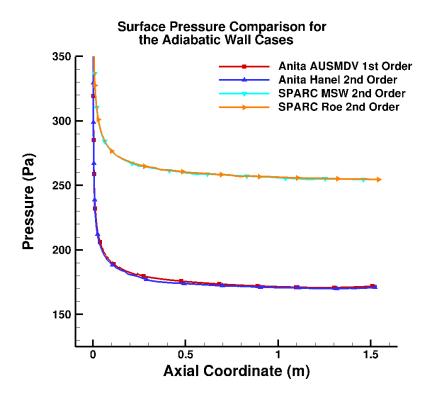


Surface Pressure Comparisons: Adiabatic



Nose

Surface Pressure Comparison for the Adiabatic Wall Cases Anita AUSMDV 1st Order Anita Hanel 2nd Order SPARC MSW 2nd Order SPARC Roe 2nd Order 8000 Pressure (Pa) 6000 4000 2000 5E-05 0.0001 0.00015 0.0002 Axial Coordinate (m)

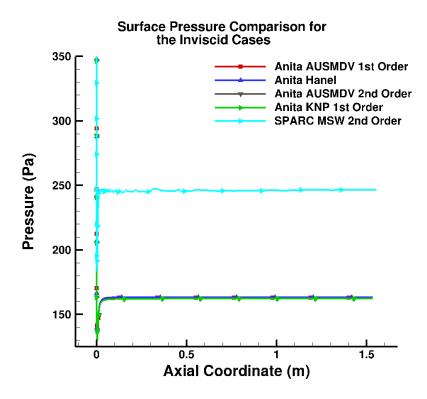


Surface Pressure Comparisons: Inviscid



Nose

Surface Pressure Comparison for the Inviscid Cases Anita AUSMDV 1st Order **Anita Hanel** Anita AUSMDV 2nd Order Anita KNP 1st Order 8000 SPARC MSW 2nd Order Pressure (Pa) 6000 4000 2000 5E-05 0.0001 0.00015 0.0002 **Axial Coordinate (m)**



Initial Conclusions



- Stagnation line comparisons
 - All codes are very similar outliers are Tina Roe Capatelli and Tina Roe NASA (density and Mach plots)
- Surface comparisons
 - Nose comparisons are very similar outlier SPARC Roe
 - Full vehicle comparisons show differences
 - Heat flux
 - SPARC MSW and SPARC Roe distinctly different
 - SPARC has slightly different heating trend compared to Anita
 - Pressure
 - All codes predict similar pressure on the nose
 - Frustrum pressures within each code are all very similar
 - Between codes the pressure differs significantly
- Wind tunnel data update
 - Data originally marked as export controlled and are currently being reviewed for release.